The Man-Machine Integration Design & Analysis System (MIDAS): Recent Improvements

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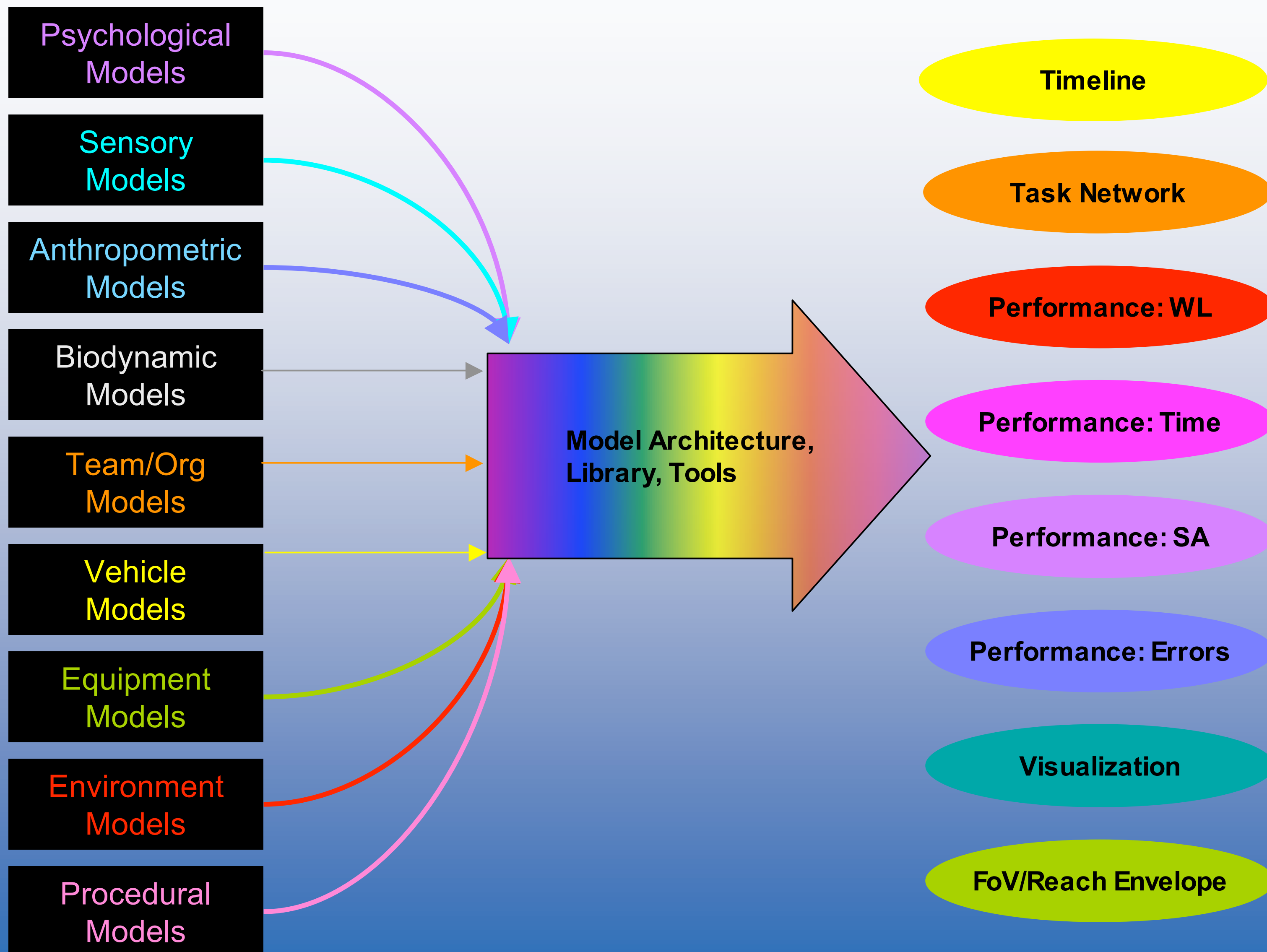
Outline

- Human Performance Modeling
- MIDAS Phase 1: Initial design
- Early applications
- MIDAS Phase 2: Move from Lisp to C++
- Recent applications
- MIDAS Phase 3: PC Port/Integrate Apex

Human Performance Models: Components



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Human Performance Models can…

- Generate hardware, software, training requirements for tasks that will involve human operators
- Depict operators performing tasks in prototype workspaces and/or in remote or risky environments
- Perform tradeoff analyses among alternative designs and candidate procedures, saving time and money
- Identify general human/system vulnerabilities to estimate overall system performance and reliability
- Provide dynamic, animated examples for training and developers
- Generate realistic schedules and procedures

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Phase 1

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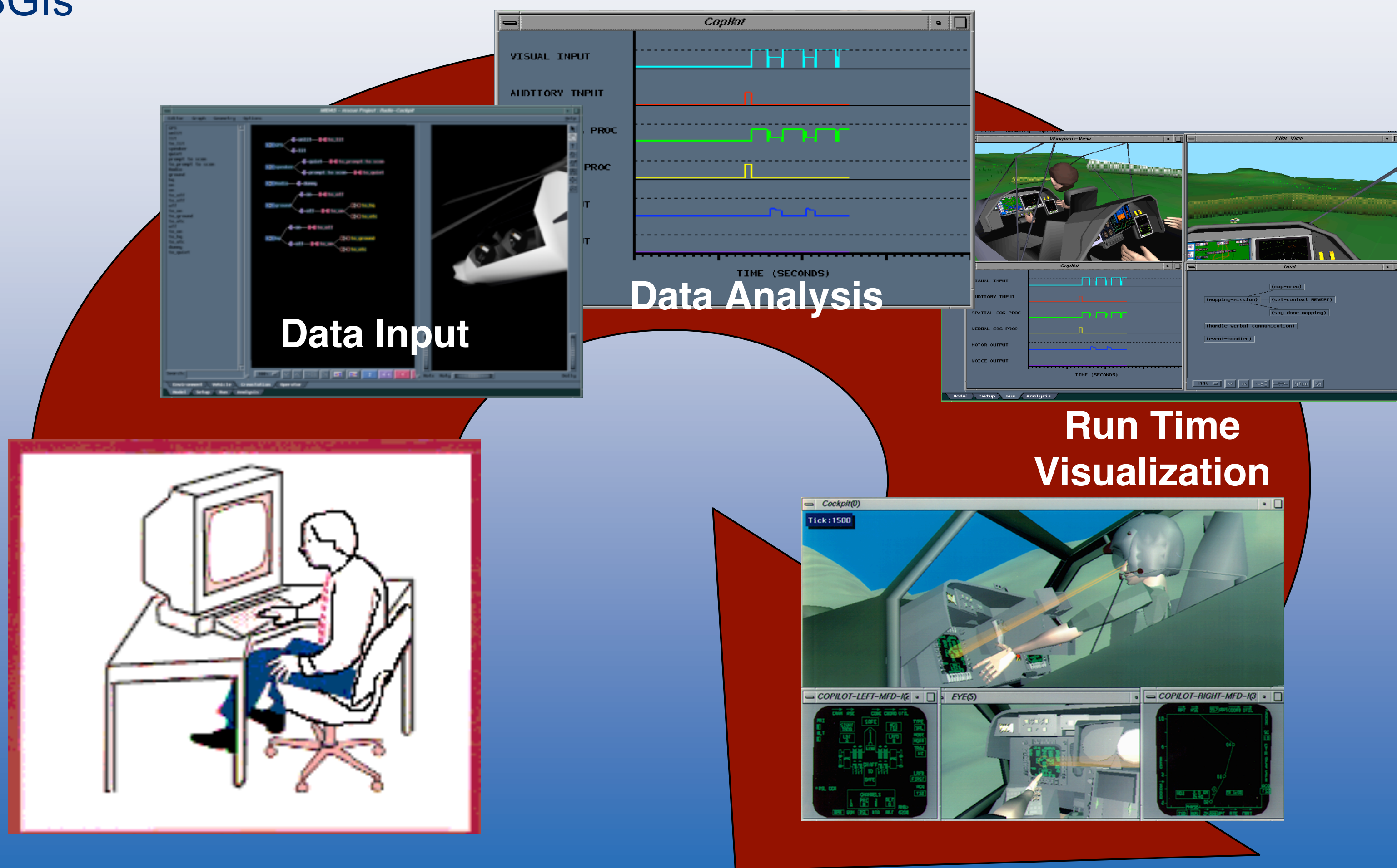
Overview

A comprehensive suite of computational tools - - 3D rapid prototyping, models of perception, cognition, response, real- and fast-time simulation, performance analysis, visualization - - for designing and analyzing human/machine systems was developed primarily in Lisp on a fleet of SGIs



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Features

- ❖ Pioneered the development of an engineering design environment with integrated tools for rapid prototyping, visualization, simulation and analysis
- ❖ Advanced the capabilities and use of computational representations of human performance in design including a state of the art anthropometric model (Jack®)
- ❖ Flexible enough to support a range of potential users and target applications

But….

- ❖ Component models written in Lisp, Fortran, C, C++
- ❖ Required a suite of SGI machines
- ❖ Modeled a single operator
- ❖ Time based rather than event based; scheduler established optimal inter-leaving of task components
- ❖ No emergent behaviors

Richmond, CA Police: 911 Dispatch

Goal: Upgrade the facilities and procedures used in the 911 dispatch facility

Accomplished:

- ❖ Modeled control console and dispatch activities in MIDAS
- ❖ Evaluated prototype graphical decision aid

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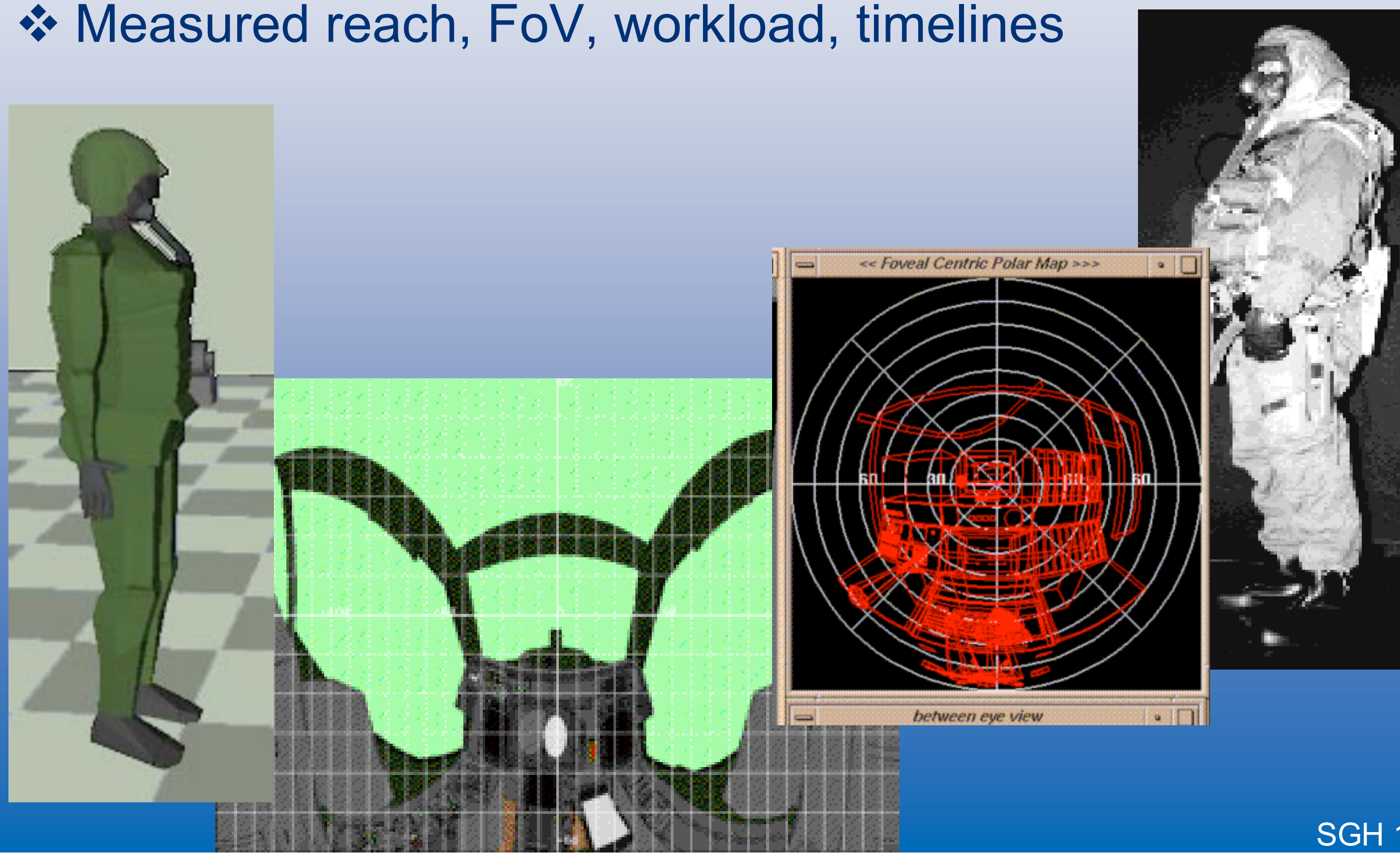
US Army Air Warrior

Goal: Establish baseline performance measures for crews flying Longbow Apache with and without MOPP gear

Accomplished:

- ❖ Modeled copilot/gunner with Jack® (95^{th} male <> 5^{th} female)
- ❖ Rendered cockpit using CAD files from manufacturer
- ❖ Simulated performance of more than 400 activities
- ❖ Measured reach, FoV, workload, timelines



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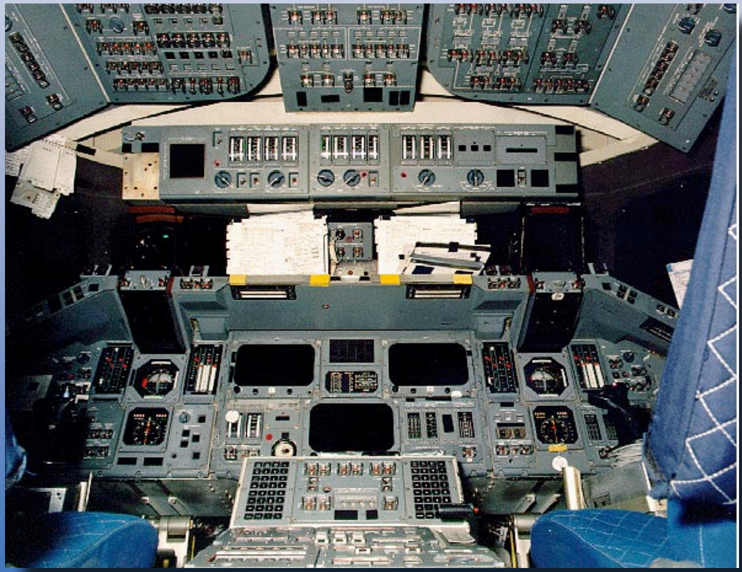
NASA Shuttle Upgrade

Goal: Support development of an advanced orbiter cockpit with an improved display/control design

Accomplished:

- Created virtual rendition of current shuttle cockpit
- Conducted simulation of first 8 min of nominal ascent
- Provided quantitative measures of workload/SA, timing



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Phase 2

Features

- Decreased model development from months to weeks
- Increased run-time efficiency from 50x RT to near RT
- Multiple operators
- Modeled external vision, audition, situation awareness
- Conditional behaviors emerging from interaction of top-down goals and environmentally driven contexts
- Option of non-proprietary "head & hands" model

But…

- The interface still user *un*-friendly
- SGI platform
- Cognitive models no longer state of the art
- Performance moderating functions not integrated

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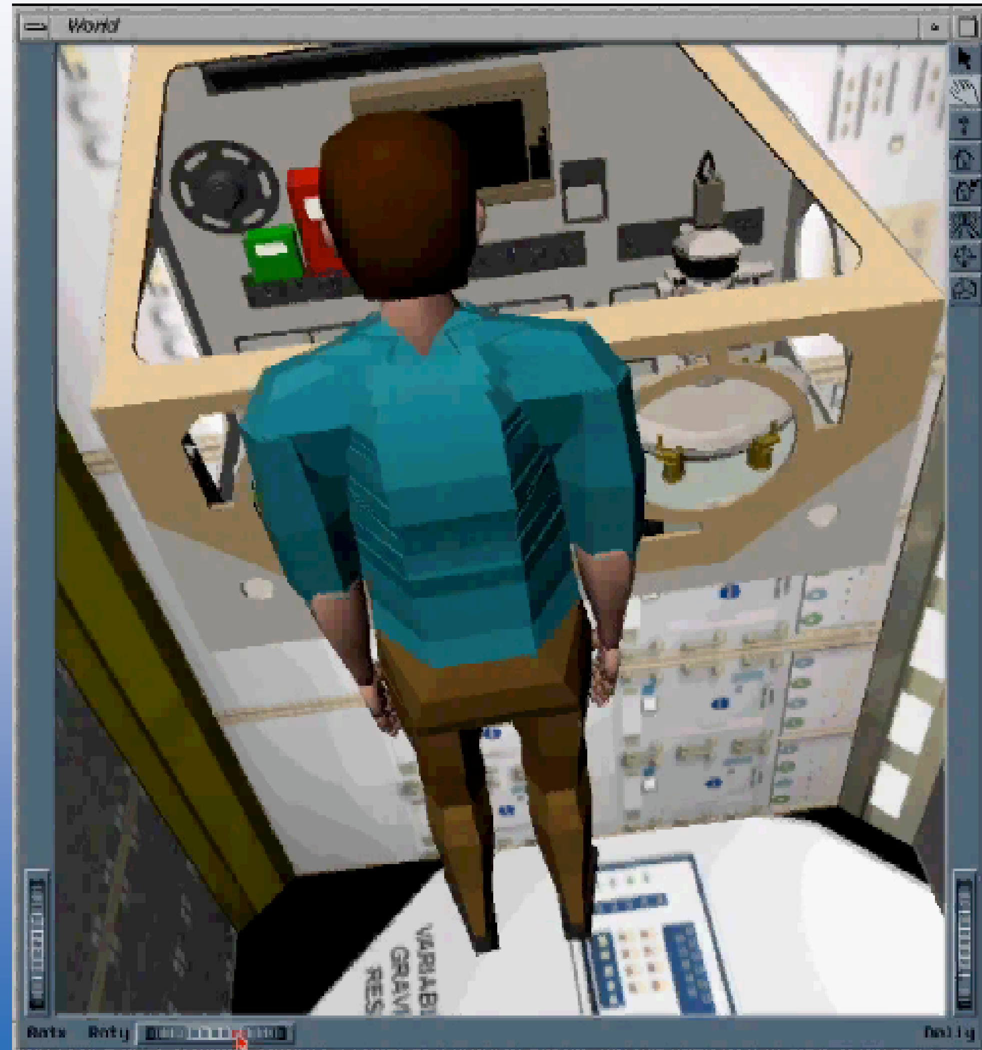
Anthropometric Models

- Anthropometric models provide an animated, 3D graphical representation of one or more modeled human operators for visualization
- Jack ® (developed at U Penn/distributed by UGS): full-body figure & realistic movements
- Head and Hands model: government-developed representation adequate for many purposes for users without a Jack license

Crew Station/Equipment Models

- The “crew station” is a collection of equipment with which operators interact
- Crew station models may be given a graphical representation for animation
- Multiple crew stations per vehicle and multiple operators per crew station possible



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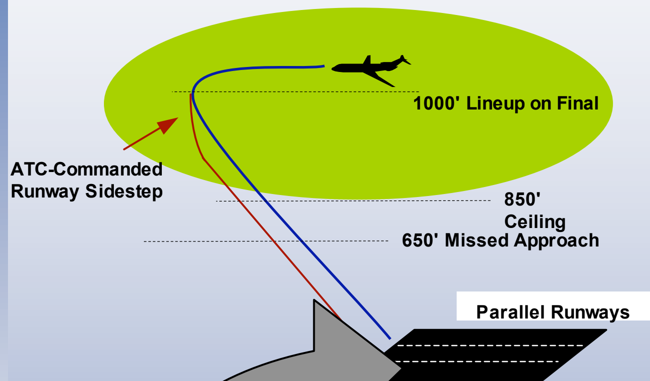
Comparison of Models to Simulator Data

Nominal baseline approach/landing and late runway reassignment (sidestep) with and without SVS display



Air MIDAS
San Jose State University

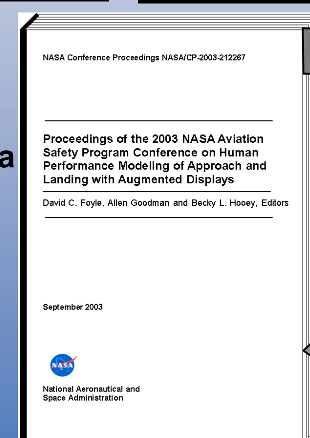
A - SA
U of Illinois

ACT-R/PM
U of Illinois
Rice University

D-OMAR
BBN Technologies

IMPRINT/ACT-R
MAAD & Carnegie Mellon

Goodness-of-fit of individual model outputs to empirical data


NASA Conference Proceedings NASA/CP-2003-212267

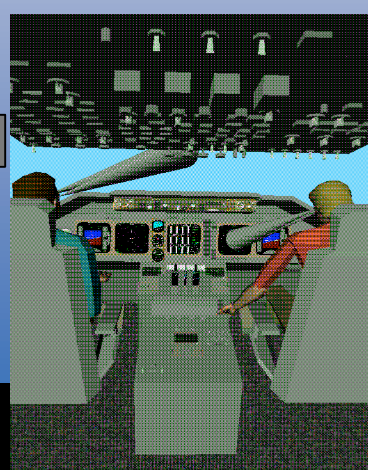
Proceedings of the 2003 NASA Aviation Safety Program Conference on Human Performance Modeling of Approach and Landing with Augmented Displays

David C. Foyle, Allen Goodman and Becky L. Hooey, Editors

September 2003

National Aeronautical and Space Administration

Preliminary timeline, SA, attention, wkld, analysis,task execution times error vulnerabilities



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Nominal Approach & Landing Simulation

- PF scanning for TFX, runway
- PNF monitoring PFD, Nav
- PF/PNF monitoring radio
- Flaps 30º/set & confirm
- PF requests before landing checklist
- PNF checks/responds hear down
- PF confirms visually/verbally
- PNF checks/responds flaps 30
- PF confirms visually/verbally
- PNF checks/responds speed brakes set
- PF confirms visually/verbally
- PNF declares checklist complete
- PF sets/declares DA at 650
- PNF visually confirms DA set
- Note passing FAF
- Confirms final descent initiated

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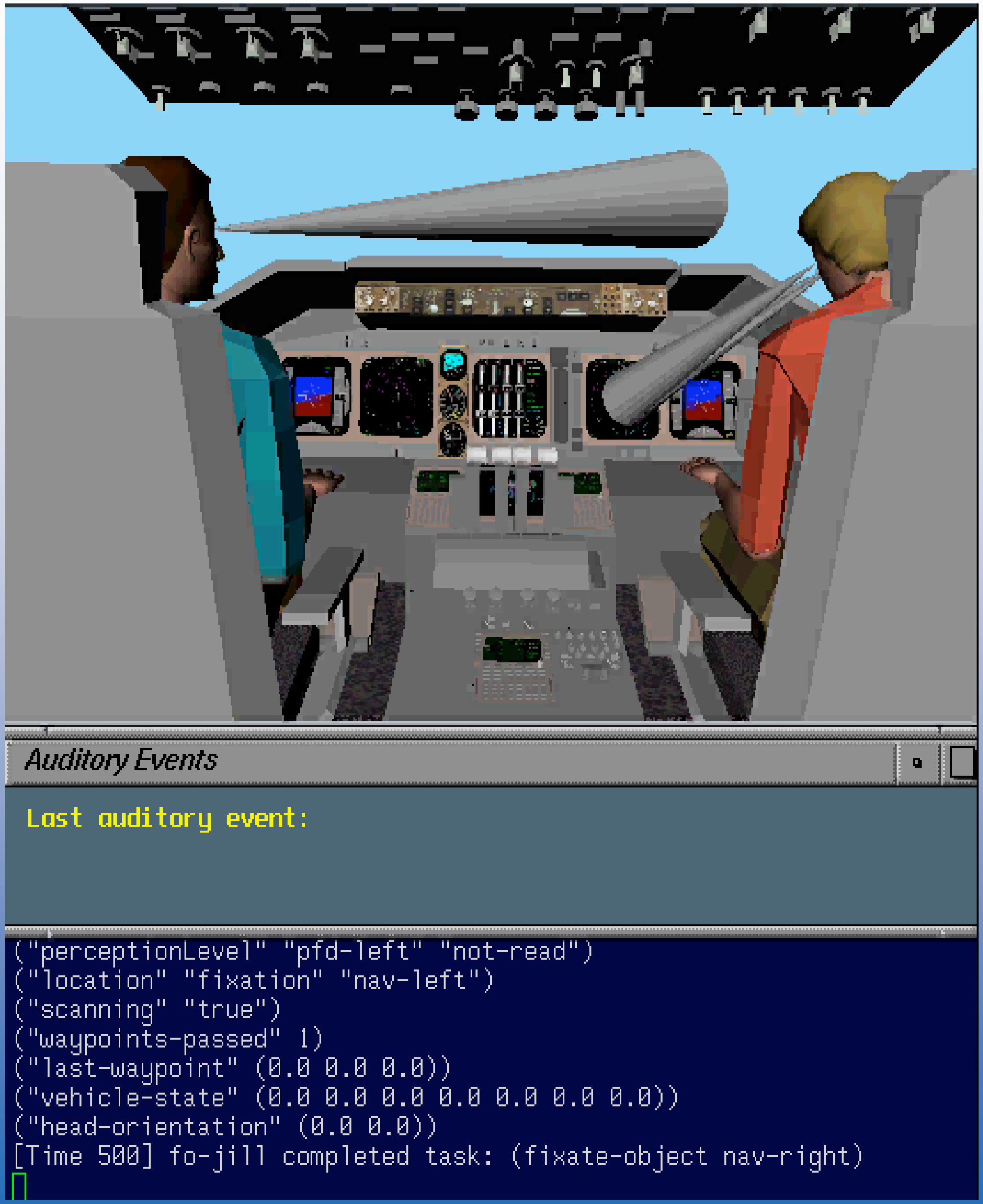
Traffic Call During Approach

- Final approach checklist is complete
- ATC call with traffic advisory
- Both pilots scan for traffic “I don’t see it”
- Neither pilot notices as the decision altitude is passed
- After the fact, the First Officer notices: “We’re past FAF and not descending”
- Crew must decide whether to continue with the approach or abort



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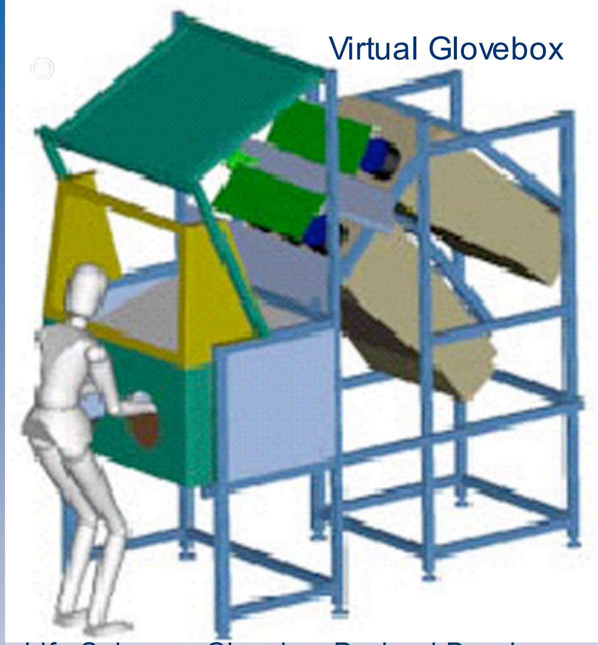
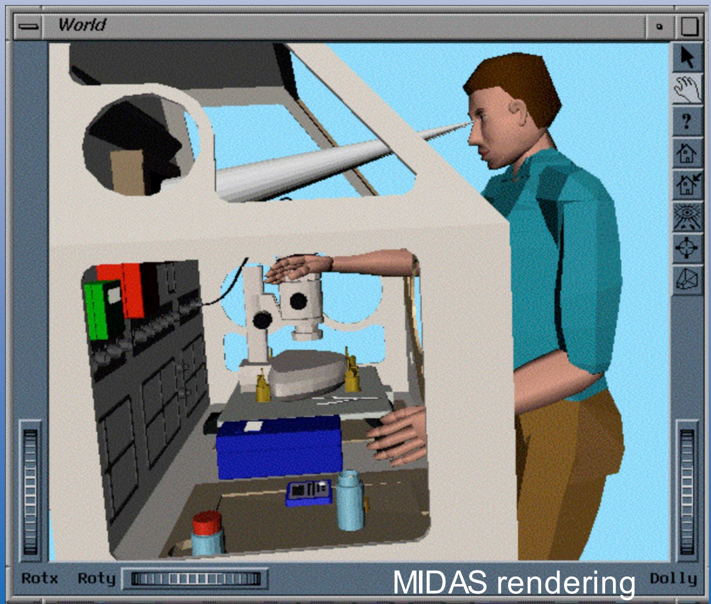
Life Sciences Glove Box



Life Sciences Glovebox Payload Development Unit received at Ames from the National Aerospace Development Agency of Japan (NASDA)

Goal: Predict astronauts' performance of complex experiments designed to answer questions about living organisms' adaptation to the space environment

Objectives: Evaluate feasibility of following proposed procedures within time/performance constraints; ID factors that will increase risk of mission failure [e.g., waiting too long to photograph slides; interruptions; task requires (unavailable) resource(s)]



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Life Sciences Glove Box Simulation

Challenges:

- Astronauts must follow detailed instructions within strict time constraints; failure to do so introduces risk of science mission failure
- Predicting interactive influences of microgravity (posture, bracing, precise movements, placing, moving, stowing) when developing and evaluating procedures
- Watching an animated dry run enables efficient communication among scientists, implementers, astronauts; more effective training

The Task:

- Turn on experimental equipment (monitor, microscope, camera)
- Measure cell density/viability for each of 6 samples
  - Invert sample vial
  - Place aliquot of sample on slide
  - Place drop of viability stain in sample
  - Record time on sample record
  - Place cover slip on slide
  - Observe on microscope
  - Take photographs within specific time window
- Dispose of trash, return vials to containers, turn equipment off

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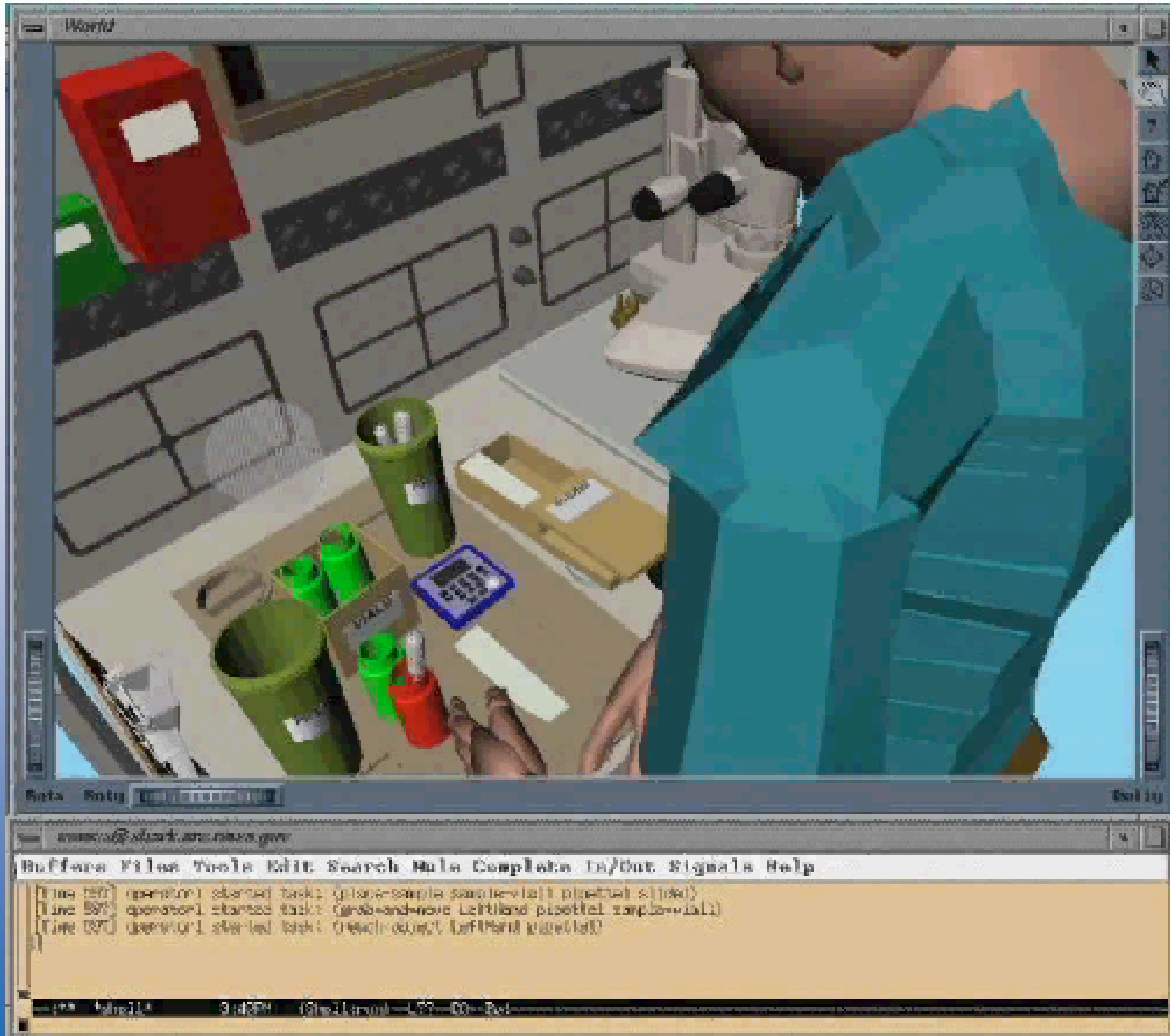
Cell Staining/Photographing Experiment



Phase 3

MIDAS v3.0 Features

- Runs on high-end PC
- Simple model of microgravity influence on *performance*
- Physics model of microgravity impact on *objects* available
- Simple within-task fatigue model implemented
- Fatigue state model (U Penn/Astronaut Scheduling Assistant) selected
- Notion of task duration - - how long a task *should* take as well as how long it *did* take
- Grasping, moving, manipulating objects in workspace
- Apex will become the heart of the Task Manager and enable multi-tasking, task prioritization, shedding, deferral, resumption
- Task primitive definitions include failure mode(s) (time/quality); result in emergent behaviors
- Mission success/performance measures computed: vulnerability to error, slipped schedules; performance degradation

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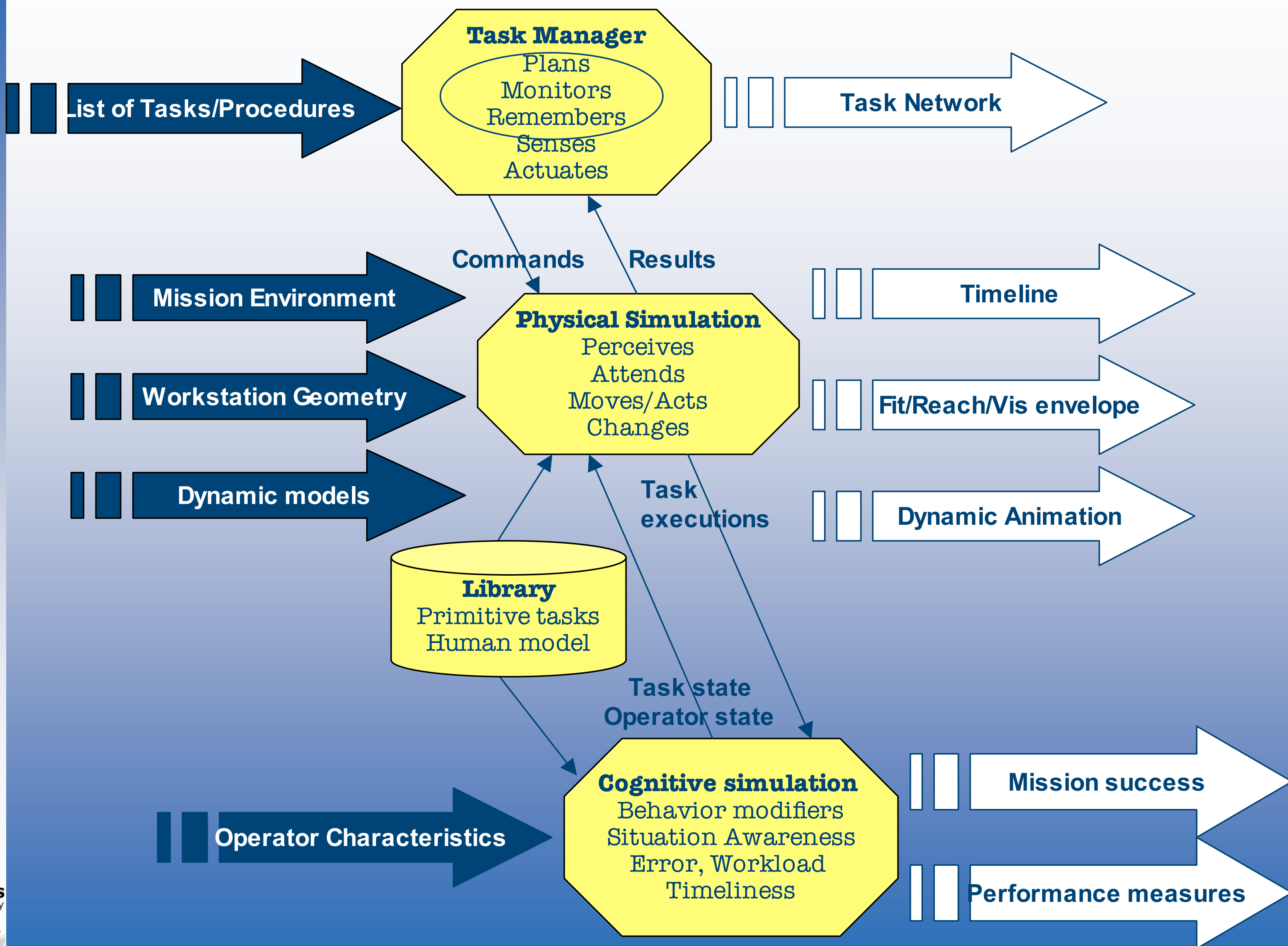
MIDAS v3.0 Structure



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Typical Outputs

Overall Attention Data Analysis
(cell-3.run)

Total Simulation Time: 83.1 Seconds

	VISUAL	AUDITO	SPATIAL	VERBAL	MOTOR	VOICE
MEAN	3.46	0.00	1.24	0.00	2.57	0.00
S.D	1.57	0.00	0.74	0.00	0.96	0.00
LOWER 95% C.I	3.35	0.00	1.19	0.00		
UPPER 95% C.I	3.56	0.00	1.29	0.00		
MINIMUM	0.00	0.00	0.00	0.00		
MAXIMUM	10.18	0.00	4.98	0.00		

Total Simulation Time: 83.1 Seconds

Overall Error Data Analysis

	ERROR %	TIME PEN	QUALITY
MEAN	16	157	0
S.D	25	21	0
MINIMUM	1	150	0
MAXIMUM	90	200	70

Overall Attention Data Analysis
(cell-1.run)

Total Simulation Time: 12.0 Seconds

	VISUAL	AUDITO	SPATIAL	VERBAL	MOTOR	VOICE
MEAN	3.36	0.00	1.09	0.00	2.05	0.00
S.D	1.07	0.00	0.35	0.00	0.67	0.00
LOWER 95% C.I	3.17	0.00	1.03	0.00	1.93	0.00
UPPER 95% C.I	3.55	0.00	1.15	0.00	2.17	0.00
MINIMUM	0.00	0.00	0.00	0.00	0.00	0.00
MAXIMUM	3.70	0.00	1.20	0.00	2.60	0.00

Total Simulation Time: 12.0 Seconds

Overall Error Data Analysis

	ERROR %	TIME PEN	QUALITY
MEAN	81	150	0
S.D	28	0	0
MINIMUM	2	150	0
MAXIMUM	90	150	99

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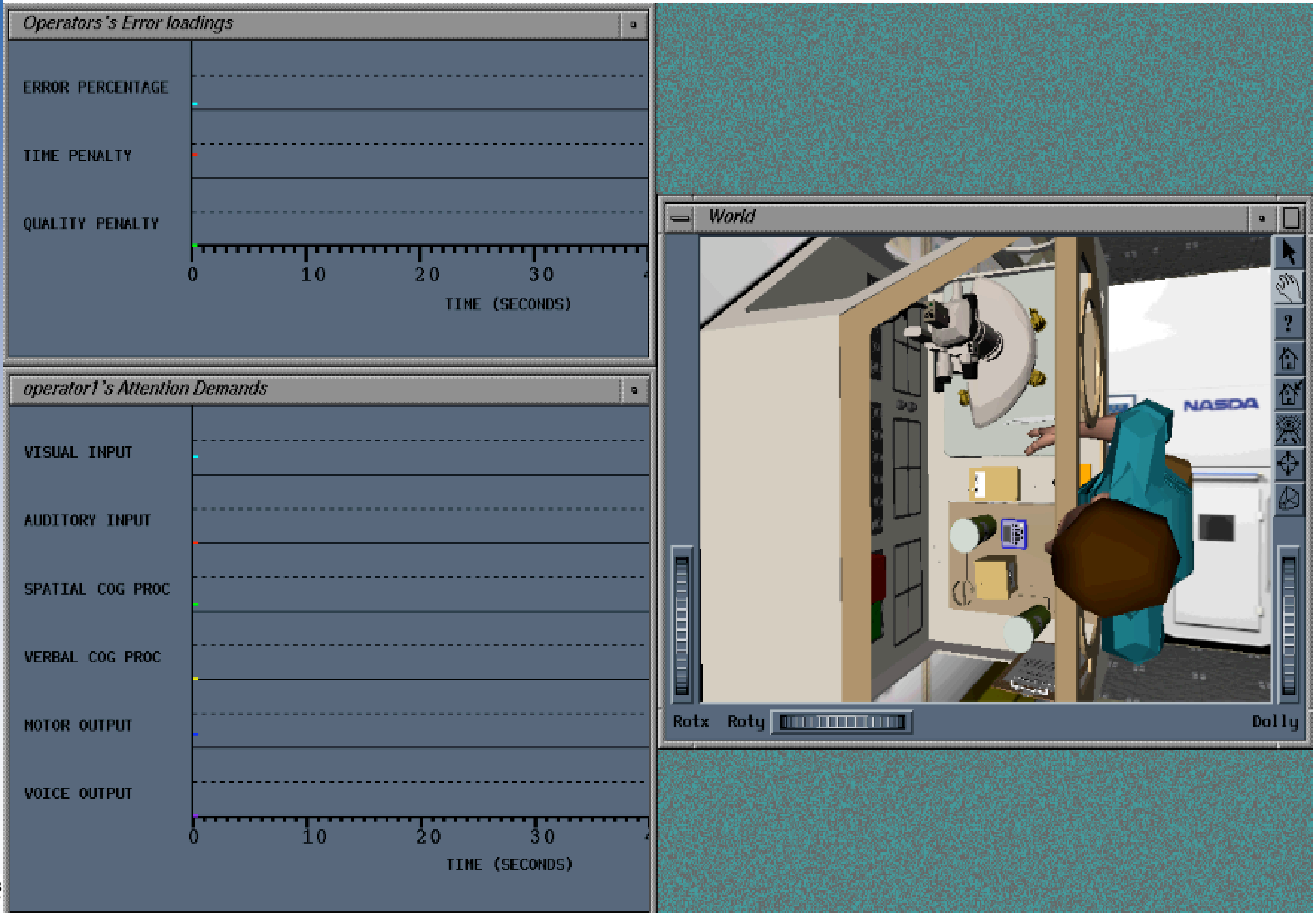
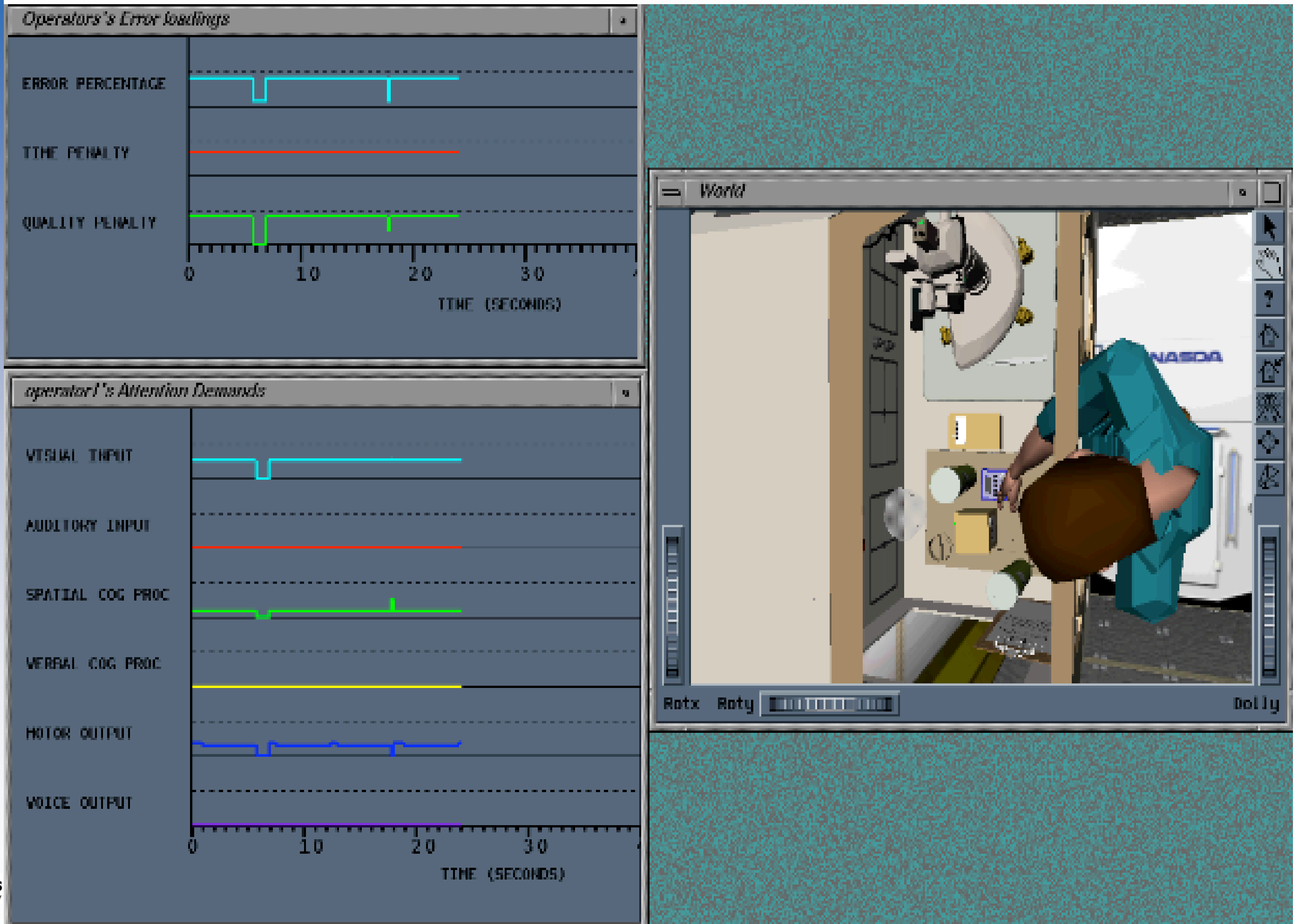
"Fresh"



Operators's Error loadings
ERROR PERCENTAGE
TIME PENALTY
QUALITY PENALTY
0
10
20
30
TIME (SECONDS)
operator1's Attention Demands
VISUAL INPUT
AUDITORY INPUT
SPATIAL COG PROC
VERBAL COG PROC
MOTOR OUTPUT
VOICE OUTPUT
0
10
20
30
TIME (SECONDS)
World
NASDA
Rotx
Roty
Dolly

"Tired"



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Conclusion

- MIDAS gives users the ability to model the functional and physical aspects of operators, systems, and environments and bring these models together in an interactive, event-filled simulation for quantitative and visual analysis

- The interplay between top-down and bottom-up processes enables the emergence of unforseen, un-scripted behaviors

- MIDAS 3.0 features a PC platform, a significantly enhanced cognitive model (Apex), and a suite of performance modifying functions, resulting in a more flexible and useful tool for representing humans operating in a variety of environments to a broader range of users

- The government has done what it set out to do - - spur development of human performance modeling tools integrated into a design environment and our goal goal continues to be to add functionality with each new application

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